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MILA: Low-cost BCI framework for acquiring EEG data with IoT

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ABSTRACT

The brain is a vital organ in the human body that acts as the center of the human nervous system. Brain-computer interface (BCI) uses electroencephalography (EEG) signals as information on brain activity. Hospitals usually use EEG as a diagnosis of brain disease. Combining EEG as part of IoT (Internet of Things) with high mobility is challenging research. This research tries to make a low-cost BCI framework for motorcycle riders. Analysis of brain activity from EEG data when motorcycle riders turn left or turn right. Therefore, the method of further installation must produce the right features to obtain precise and accurate brainwave characteristics from EEG signals. This research uses the concept of IoT with software engineering to recording human brain waves so that it becomes a practical device for the wearer. The purpose of this study is to create a low-cost BCI framework for obtaining EEG Data.

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1. INTRODUCTION

Research on how the human brain works more clearly has become a hot topic for discussion in biomedical [1]. EEG, EOG, EKG, and EMG acquire human electricity data [2]. One of the most common uses of bio-signals is EEG or Electroencephalography. Not only in medical equipment, but also in brain-computer interface (BCI) [3]. Use a brain-computer interface, the system must be able to produce results quickly, and there is no discontinuity between input and response that will be made by a computer that can use as a real-time system [4].

EEG will make it easier for research or to monitor brain disorders. However, the signals by EEG need to prepare so that brain abnormality can detect automatically. Therefore, to produce the right features to get the characteristics to approve the EEG signal requires a preprocessing method [4, 5]. Vehicle accidents have become commonplace due to several causes including the increase in vehicles in large numbers, the presence of drivers who are not adept at driving their vehicles, the presence of drivers who do not obey with traffic signs, and then drivers who force to drive their vehicles when there are tired [6]. According to world statistics on traffic accidents by the World Health Organization in 2004, the total number of victims of global traffic accident injuries will increase by 65% in low and middle-income countries. These traffic accidents grow to 80% in the period of the years 2000 to 2020 [7]. With increase socio-economic development, according to data by the Traffic Management Bureau of the Ministry of Public Security in China, at the end of 2017, the number of vehicles in China reach 310,000,000, with an increase of 11.85% per year. Correspondingly, an increase in traffic accidents [8]. In this study, the author will build a framework for wearable BCI for the motorcycle driver. The framework combine IoT and the Low-Cost BCI concept

2. RELATED WORKS

2.1. Electroencephalography

Neurons are the center of the entire nervous system is the human brain Consisting of billions of cells. Brain waves are communicating and emit electric waves that neurons produce. To measure brain waves, it can use an electroencephalogram (EEG) [9]. Brain waves produce frequencies that vary between 0.5-30 Hz and classified into delta waves, theta waves, alpha waves, and beta waves. Each stream has different characteristics and shows a person’s mental state.

Electroencephalography (EEG) is a test to detect brain waves. This signal record by an Electroencephalography device, which is a hardware device that functions to record the electrical activity of the brain wave [10]. The working principle of EEG detects the electrical activity of the brains of people by recording silver electrodes installed by trained technicians on the scalp [3, 11]. In this study, researchers used a tool from Neurosky Mindwave, which functions like an EEG tool to record brainwave data at a more affordable cost compared to using an actual EEG tool.

2.2. Low-cost BCI

Brain-computer interface (BCI) is a system to enable direct communication between humans and computers/machines without using normal channels from the nervous system of the human brain [12]. Another definition states that BCI is a system consisting of a set of tools for measuring nerve signals from one and a method or algorithm that maps the results of decoding into behavior or action by a machine. From the above definition, a BCI system has three main components: data acquisition system, signal processing, and application interface [1, 13, 14].

The brain-based electroencephalography (EEG) interface (BCI), due to the nature of the non-invasive, portable, and temporal resolution, is widely used in the field of neural engineering. BCI technology makes it possible to utilize brain signals, generated as a result of certain stimuli, and estimating the user’s goals. For such applications, a low-cost portable system needed [15]. One example of a low-cost EEG BCI is Neurosky Mindwave that uses one electrode. System portability and affordability are more suitable for practical use in research activities.

2.3. IoT framework

In the IoT (Internet of Things) era, wearable devices to measure the physiological condition of humans bodies such as Electroencephalogram (EEG) [16]. The components of IoT devices consist o f sensors, actuators, power modules, the platform, communication module, andnetwork technology that may or may not be applied [17, 18]. IoT (Internet of Things) is an advanced concept of ICT (Information Communication Technology), where all devices and services collaborate while reducing human intervention so it can reduce the workload of humans according to their needs. All sensors in the Neurosky Mindwave device can be one of the data resources in research and medical records [19, 20].

To implement IoT in the real world, that is necessary to implement integrated infrastructure technology. There are three technologies for transferring data from an IoT device. First, it is a fundamental element for pulling and extracting data from objects, second, Near Field Communication (NFC) network technology for exchanging information for short distances, and third, a program for recording the data [17, 21, 22]. The Secure IoT Data Model is a specification of the different types of data that are collected, streamed, stored, and processed by the SecureIoT platform. The purpose of the Data Model is to provide a standard specification for all parts of the Secure IT platform for the different types of data that may be exchanged between them [23, 24]. In this research, the IoT device used is Neurosky Mindwave, which is a tool to record human brain wave activity where this device consists of a headset and a USB Bluetooth and then uses a program to record the human brain wave data in the Google spreadsheets.

3. RESEARCH METHOD

3.1. Framework architecture

Figure 1 shows hows the Framework is working. This research uses Neurosky Mindwave as Low-Cost EEG Device. The EEG driver connected to the Framework as an IoT sensor device to record the EEG data and use a Python programming language to process the data in the Google spreadsheet. Figure 1 explains the process of taking brainwave data using the Neurosky Mindwave. The Neurosky Mindwave device must connect with the driver to the laptop or raspberry pi and configure the port in the Python program code to record brainwave data and stop recording at the specified finish line using stopper. After that, the brainwave data will store to Google spreadsheet.

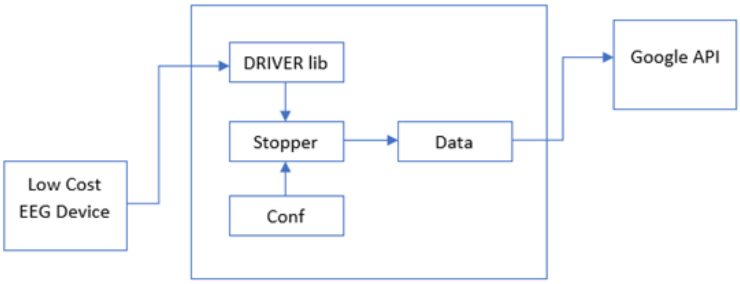


Figure 1. Framework Architecture of MILA

3.2. Data acquisition

Data Acquisition is the stage used to obtain data that later, the data used in the system processing. Data retrieval is done on the subject using a MILA Framework. In this study, the method used for data collection conducted on subjects aged around 22-24 years totaling ten people. There is a right turn and left turn test using MILA Framework to get the parameters for processing by the system later [25].

The recording process carried out as many as ten sessions. Each subject tested ten times when turning right and turning left. The process of recording mind waves is a stage for collecting data that aims to analyze brain signals. EEG signal recording uses a computer that has a Python application installed, and it connected to the Neurosky Mindwave USB device. Neurosky Mindwave USB device is a tool to record brain wave activity.

Experiments carried out in a field that has been conditioned and made a pathway or scheme for motorcycle drivers. Each test track has a length of about 20 m and a turn along the 5 m. Motorcycle drivers must turn on the signal lights at the predetermined mark on each turn condition. Figure 2 is the field scheme for data recording. Each motorcycle driver conducted a test of 10 sessions on each turn condition.

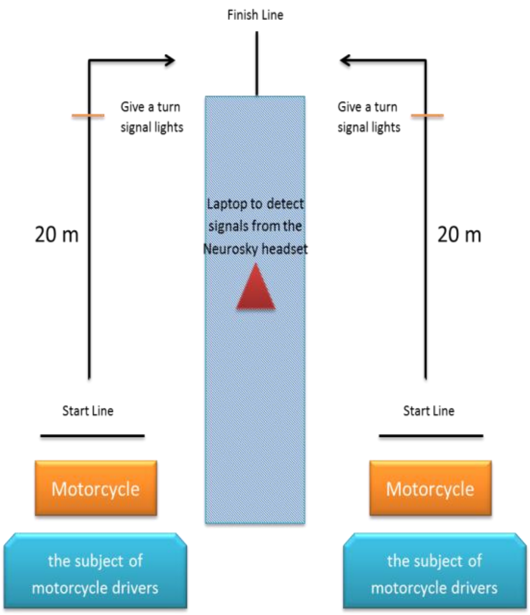


Figure 2. Data Recording Track Scheme

After the driver attaches the Neurosky Mindwave device, make sure the USB port settings are appropriate, and the battery condition must also be adequate. The position of the operator who records data through the laptop should also not exceed 20 meters from the subject that wears the Neurosky Mindwave device. Before starting, make sure no objects are blocking the area so that the Neurosky Mindwave signal from the USB device can be appropriately detected. Python program code as shown in Figure 3 for recording brainwave data also as a stopper and configuration area. The python program in Figure 3 contains port settings, insert data to Google spreadsheets, and a warning message will appear if the device not connected.

```
import time
import gspread
from oauth2client.service_account import ServiceAccountCredentials
from NeuroPy import NeuroPy

#neurosky initialization
port = "COM4"
mid = "1425"
rate = 0.001953125

#google spread initialization for access data via internet (IoT)
scope = ['https://spreadsheets.google.com/feeds', 'https://www.googleapis.com/auth/drive']
creds = ServiceAccountCredentials.from_json_keyfile_dict("client_secret.json", scope)
client = gspread.authorize(creds)
sheet = client.open("data_brain_waves").get_worksheet(1)

headset = NeuroPy.NeuroPy(port)
time.sleep(2)
headset.start()

print("connecting")
while headset.status != "connected":
    time.sleep(.5)
    if headset.status == "standby":
        headset.start()
        print("retrying connect..")
print("connected")

setData = True
while setData:
    try:
        #insert the data into google spreadsheet
        sheet.insert_row(str(headset.rawValue), 0)
        time.sleep(rate)
    except KeyboardInterrupt:
        setData = False
        headset.stop()
```

Figure 3. Python Code for MILA

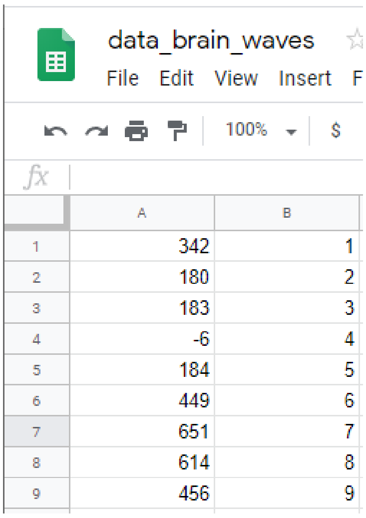
3.3. Signal acquisition

This signal acquisition carried out by using code to get a raw signal from the Neurosky Mindwave tool. The data through recording using the program is automatically upload and save to google spreadsheets. The code also acts as a starter and stopper for recording mind waves signal. After recording, the mind wave recordings can process to the next stage. The sampling rate value on the Neurosky Mindwave device is 247Hz, 247hz is a value when the Neurosky Mindwave tool is running and return 247 sample data each second. Figure 4 is the process of taking the driver's brainwave data when turning right or turning left. The driver turns left or turns right in the parking lot with a track based on the track scheme in Figure 2 so that the driver makes directions according to the rules.

Figure 4. The Brain Waves Data Collection Process Using MILA Framework

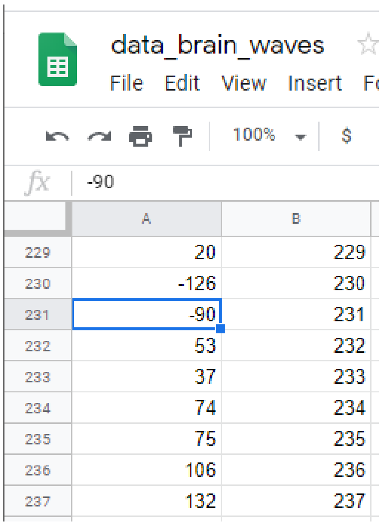
3.4. The RAW data

The RAW data can show with many applications for further analysis of the raw data of recording the brain signals in the Google spreadsheet. This data result is from the subjects of Brain waves. Figures 5 and 6 are a subject one data. The numbers in column A as shown in Figure 5 and Figure 6 in the Google spreadsheets will form graphs when processed. Positive values in the column will make the wave direction up. If the value is negative, it will make the wave direction down. From Figure 5 and Figure 6, there are columns A and B, column A as a result of recording data from the Neurosky Mindwave device, and column B is manually input to count the number of waves in 1 second. So from the calibration results, the data obtained in column A is 247 rows. So the sampling rate of the Neurosky Mindwave device is 247 Hz. Because, at the time of the calibration of the Neurosky Mindwave tool used, the results of the data were inconsistent.



	A	B
1	342	1
2	180	2
3	183	3
4	-6	4
5	184	5
6	449	6
7	651	7
8	614	8
9	456	9

Figure 5. RAW Data on Subject 1 When Turning Right



	A	B
229	20	229
230	-126	230
231	-90	231
232	53	232
233	37	233
234	74	234
235	75	235
236	106	236
237	132	237

Figure 6. RAW Data on Subject 1 When Turning Left

4. RESULT AND DISCUSSION

Based on the results of RAW data processing in graphical form. By the comparison of brain wave oscillation data to the driver when turning right or left. Each brain wave graph has different characteristics. In this study, researchers examined motorcycle drivers when conditions turned right or left. However, the signal that Neurosky Mindwave produces requires reprocessing to detect the state of the brain signal automatically.

Therefore, a further processing method is needed to produce accurate data. The Neurosky Mindwave device records this signal. The working principle of Neurosky Mindwave is to detect electrical activity from the brains of people by recording silver electrodes installed by trained technicians on the scalp. This study aims to obtain and compare the brainwave signal frequency spectrum obtained by stimulation in the form of riding a motorcycle in the condition of turning right or left ten times each turn. The test is carried out by several volunteers who will drive the same motorcycle by turning right or left each of ten rounds. Figure 7 and Figure 8 are graphic of subject 1.

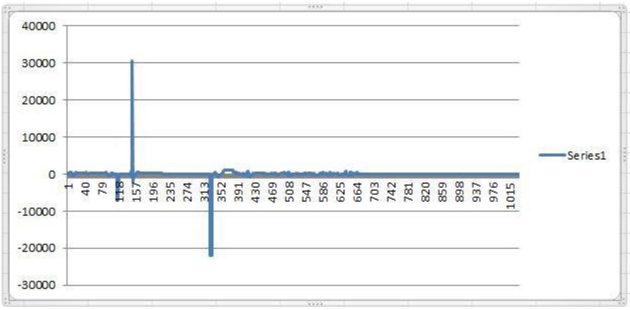


Figure 7. Subject Graph 1 when Turning Right

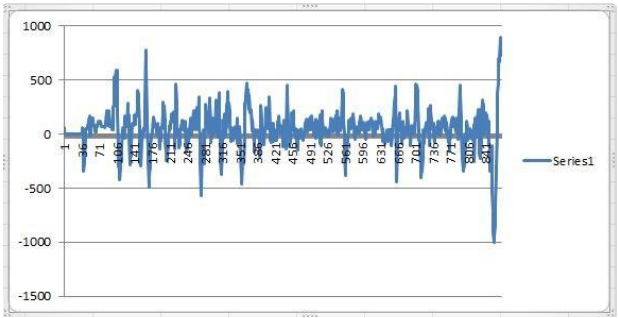


Figure 8. Subject Graph 1 when Turning Left

5. CONCLUSION

Base on the results of the study, the state of the human brain waves is always different depending on the activities they do, and other things that they think about anxiety or stress. The test results show the difference in brain condition of each subject when riding a motorcycle when turning right or left. Disturbances that can occur in the process of taking brain wave data are sweat that covers the sensor on the Neurosky Mindwave device that is in the head of the object of a motorcycle rider for testing and loss of signal from the Neurosky Mindwave tool to record brain waves. Future studies can conduct research on the prediction of turning right or turning left based on the results of brainwave signals in motorcycle drivers.

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